ON THE RECONSTRUCTION OF MOTION OF STRUCTURES FROM THEIR TIME AVERAGE LASER HOLOGRAMS

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Time average laser holography is a powerful experimental analysis tool for the investigation of structural vibrations. It has many advantages over other vibration measurement techniques. It is a whole field non-invasive method and can be exceptionally useful if the amplitudes of the analyzed vibrations are in the range of micrometers. Though there exist a number of algorithms and techniques used for the interpretation of the measured holograms [1], the reconstruction of motion of structures from those holograms is a sensitive procedure in the sense of error accumulation. Moreover, as it is shown further on, the uniqueness of reconstruction is not guaranteed.

It is quite complicated to generate structural vibrations with exactly prescribed parameters. The inverse problems can be validated only when the motion of the structure is strictly predefined and the results of the reconstruction can be compared with the defined data. Therefore there exists a need for developing numerical tools for modeling the formation of the pattern of interference bands in the virtual computational reality. Such modeling can build the ground for hybrid numerical - experimental techniques [2].

The developed numerical model comprises elastic structure described by FEM model, including optical properties of its surface, coherent laser light source, 3D optical scheme used in experimental time average holography and the holographic plate where the interferogram is recorded.

Important is the fact that the existing techniques for the interpretation of fringes are inadequate if the vibrations are not harmonic - then the decay of intensity is governed by quite different mathematical relationships, depending from the type of vibrations. Moreover, the inverse problem of the reconstruction of motion does not have unique solution even if the vibrations are harmonic. That fact is clearly illustrated by numerical simulation of the pattern of interference fringes for coupled eigenshapes and propagating waves. Though the produced interference bands are clear and distinct, the straightforward application of the motion reconstruction algorithms would lead to equivocal results.

Even more complicated situation arises when the vibrations of the analyzed surface are not harmonic. Analytical and numerical analysis of stochastic structural vibrations have shown that no intensity bands are formed at all. The intensity of illumination decreases by exponential law without the formation of interference bands. Important result is that the fact that no interference pattern is detected in the time average hologram does not necessarily mean that the optical measurement scheme is malfunctioning, – maybe the analyzed structure performs stochastic vibrations.

References

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